DETERMINANTS OF THE UPTAKE OF SOLAR PHOTOVOLTAIC BY ERC LICENCED FIRMS IN KENYA.

BY

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DECLARATION

This research project report is my original work and has not been submitted for the award of a degree or accreditation in any other institution.

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This research project report has been submitted for examination with my approval as the University Supervisor.

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DEDICATION

To my wife Caroline Wanjiru Kimani and our two kids Neema Zawadi and Amani Jelani. Thanks you very much for the sacrifices and walking with me through this academic journey. To you my parents Trizer Muthoni and Festus Muchiri thank you for your encouragement and love.

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LIST OF ABBREVIATIONS AND ACRONYMS

IPCC	-	Intergovernmental Panel on Climate Change.
PV	-	Photovoltaic
USA	-	United states of America
GW	-	Giga watts
MW	-	Mega Watts
EU	-	European Union
FIT	-	Feed-in Tariff
EROI	-	Energy return on investment
kWp	-	Kilowatt Peak
ERC	-	Energy Regulatory Commission
KEREA	-	Kenya Renewable Energy Association
RET	-	Renewable energy Targets
UNESCO	-	United Nations Education Scientific and Cultural Organization
EAA	-	Energy Alternatives Africa
ESDA	-	Energy for Sustainable Developments, Africa
AC	-	Alternating Current
DC	-	Direct Current
BIPV	-	Building Integrated Photovoltaics
LCOE	-	Levelized Cost Of Electricity
REC’s	-	Renewable Energy Credits

ABSTRACT

The purpose of this research project is to examine the determinants of uptake of solar PV in Kenya using a case of licensed solar PV firms in Kenya. This research sought to achieve five objectives with the key variables being the uptake of solar PV as the dependent variable and cost of equipments, quality of equipments, government incentives, awareness of the technology and grid access being the independent variables. The research design employed in conducting this study was descriptive research design. The study used questionnaire to collect data from the sales engineers, sales managers and company heads of solar photovoltaic contractor firms as well as vending firms. Since the target population comprised 214 solar vendors and contractors, the study used a census method with a sample size of 214 firms and a return rate of 134 out of 214 which represents 63% return rate. The data from the questionnaires was analysed using descriptive statistics and percentages. The study established that the five variables highly affect the uptake of the solar PV albeit in different magnitude. Government incentives were found to be the highest in determining the uptake of solar PV while the proximity to grid access was found to be the least. The study recommends further research to establish other factors that affect the uptake of solar PV in Kenya as the five variables though critical, were not enough to give a blanket view. The conclusions of this study is very useful to the government policy makers to understand the determinants of uptake of solar PV as well as the solar PV entrepreneurs to help them understand their consumers better besides adding knowledge to the solar PV industry.

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Solar PV involves converting sun light into electricity through photovoltaic; a process that uses semiconductors popularly known as solar cells to convert the suns radiation into electricity. According to Scheer (2001), in one hour, the sun generates energy far more than human life can consume for a year. This goes a long way to explain the energy potential of the sun standing at 150 million kilometers (about 93.75milion miles) from the earth and radiating just a portion of its energy to the earth that is far greater than the human requirements.

However, while a majority of consumers find the national power grid supply to be the most convenient source of electricity, Mollie (2014) notes that with the ever increasing fear of exhaustion of fossils energy which constitutes more than 80% of power consumed globally, most policy makers and indeed authorities all over the world have been forced to focus more on sustainable sources of power hence the push for renewable energy.

This in turn has made solar power harvesting the most commercially popularized renewable energy mainly because it’s a free and infinite resource that is available all over the earth albeit in different intensities in different parts of the world. On the other hand solar power is environmentally friendly with the cells having a long life expectancy of more than 20 years besides the fact that it enjoys a low cost of production compared to other sources of renewable energy and has minimal cost of operation and maintenance.

Deambi (2011) acknowledges that European Union is leading in solar PV power installations with key members on the top list - representing about 78% of solar power installation by 2009. According to Prieto (2013), Germany leads the pack of the global producers of solar PV followed by Italy, Japan, USA and Spain. The five countries account for over 80% of the world’s solar power generation. Interestingly though is the enthusiasm showed by China which has managed to get to top 10modules manufacturers list in the solar PV market and is widely expected to be a major player in the coming years as well as India, which according to Deambi (2011) exudes a confidence of a country inclined to exploitation of solar PV technology for large scale power generation through various initiates like the Jawaharlal Nehru National Solar Mission. The aggressiveness of India is given more weight by their new huge facility to produce 500MW of solar power in Charanka Solar Park in Gujarat state, notes Pagnoni (2014). A thought-provoking phenomenon is the changes that have happened between 2006 and 2013 on the world's top ten solar PV panel's producers with China which apparently was an underdog in the 2006 becoming the key player in 2013 notes Dent (2014).

According to Simelane et al (Eds 2011) the world power energy consumption in 2007 was estimated to be around 18trillion kWh while by 2030, the demand will have increased to 31trillion kWh of which approximately 20trillion kWh will be generated from renewable sources. In his publication "The Solar Economy: Renewable Energy for a Sustainable Global Future" Scheer (2013) argues that even if the Kyoto protocol on climate change was to be implemented in full by those countries that signed up, the best it could achieve is to bring down pollution from the fossil energy emissions to an already dangerous levels experienced in the 1990s. This therefore means that the key objective of the protocol was to curtail an escalating problem of emissions and not necessarily improve the environment. Scheer (2013) further argues that the damage already caused by the fossil energy utilization would only reduce by a mere 2% in countries that have signed up. However, he notes that the USA which contributes 25% of the global emissions is not a signed up member and therefore is not bound by the protocol. This only goes further to paint the gloomy picture of the world emissions with the global projections expected to rise by a further 10%. However, with the acknowledgement by the UN supported IPCC that a 60% reduction in emissions is crucial to stability of the world climate by 2050, there has been a deliberate push by the world authorities to adopt renewable energies as a counter measure to the global emissions and solar energy has been singled out as an efficient, cost effective, long life and sustainable energy source that can offer alternative choice to fossil energy.

Jordan (2013) notes that while the 2007 economic crisis in the US sent shocks on the world economy and many sectors are struggling to recover to date, the solar energy industry has experienced a global revolution with declining costs of up to 70% besides the low maintenance especially due to the fact that PV panels comprise of immovable parts. According to a survey carried out on the solar employers in the USA, Jordan (2013) claims that, over 90% of all the companies installing solar systems work with PV products. Jordan also notes that by 2011, USA had installed 4gw of solar power to be the fourth highest generator in the world. In 2011 alone, the installations of domestic PV installation went up by 109% which signifies an additional 758MW of solar power supply. Acknowledging California state to be the leading market in USA, Kris (2010) argues that the installations in California alone increased by 95% in 2008 while the installations of solar PV in USA market increased by 63% in 2008 from the installations done in 2007 and that the size of the solar PV systems has kept increasing with the residential sector still dominating the market. In 2008, USA had solar PV installations generating around 843MW of solar power. At the same time Deambi (2011) points out that one of the key drivers of the growth of the solar power uptake especially in California and New Jersey is the subsidy programs that have been instituted while in the other states the authorities have more or less adopted an obligatory requirement.

According to Bhandari (2010), solar PV systems are very promising future source of global energy especially with the declining cost at a rate of 20% annually, a trend that is expected to continue in the future. Bhandari (2010) in his publication “Role of Grids for Electricity and Water Supply with Decreasing Costs for Photovoltaics” predicts that the cumulative PV systems installations in Germany alone are likely to reach 98GW and 4400GW globally by the year 2060 further illustrating the potential and interest in solar energy. However, by 2014 the cumulative generation is likely to be at 5GWin Germany. While acknowledging the number one status of Germany in the world and commanding 68% of EU market by 2009, Deambi (2011) explains that the key drivers to the number one status of Germany are mainly the good financing channels available, general public awareness of the PV technology as well as the proven FIT scheme.

These factors have led the growth of Solar PV installations generating 3.8GW in 2009 up from 1.8GW in 2008. However, Jordan (2013) appreciates that Germans are 30% more efficient compared to USA with the Solar PV industry employing about 100,000 persons compared to USA's 120,000 because Germany generates almost double of USA's solar power. Jordan (2013) expresses fear of the German Solar industry due to the withdrawal of government incentives which forced about 12 manufacturers to file for bankruptcy between 2011 and 2012. However, with the closure of the weak competitors and the innovation of the thin film market coupled with a tremendous human capital resource, Germany is still regarded as very strong and therefore is able to mitigate the current challenges and emerge a winner.

On the other hand, Foster (2009) describes Japan as one of the advanced and successful economies in the use of solar PV systems generating one fifth of the global solar power. While the government subsidies where phased out in 2006, the country continues to grow its Solar PV systems with Ohta city leading in grid- tie homes. Deambi (2011) notes that the relaunch of Japanese residential PV system initiative saw the country install 484MW in 2009 setting in motion an ambitious plan to install 28GW of solar PV power by 2020 and a further 53GW by 2030.Deambi (2011) estimates that by 2014, solar PV systems installed in Japan could reach between 1.2GW and 2. 4GW depending on the government policy of the industry.

Foster (2009) adds that Japanese population ranks highly among the world public that is well appraised not only with the solar systems but also the benefits of the same. Nonetheless, Jordan-Korte (2011) notes that while Japan was earlier leading in solar PV systems in the world, times have changed with different governments around the world adopting policies that favour the adoption of solar PV systems which are largely responsible for change in positions. Today, Japan stands third after Germany and Italy. Nevertheless, Japan is still considered as very aggressive in pursuit of solar power generation in the world with key brands like Kyocera, Sharp, and Sanyo being world leaders in the PV market according to Geller (2012).

According to Pagnoni et al (2014), Italy just like Germany has put forward impressive price supports of solar PV systems as well as the FIT for solar PV systems that have led to a high growth of the industry in the recent past. Further to the introduction of FIT in 2007, Italy's solar power output grew from 120MW to excess of 16,000MWin 2013 mitigating the unstable fossil fuels energy which it largely imported from Iran hence creating a more energy dependent front. However, these incentives are not expected to last forever and Fabiana (2011) explains that the policy plan is to reduce the incentives by 6% in 2012 and again in 2013 with the Solar PV systems entering the market in 2014 being under different decree. Palz (Edited 2014) adds that in 2012, the solar PV systems installations in Italy generated over 5% of power needs in Italy.

Prieto et al (2013) articulates that by the end of 2011, Spain had an installed capacity of 4,237MW of solar power driven by the renewable energy policies modeled around the Germans incentive guidelines of FIT and private investment in solar PV systems technologies as well as Spanish geographical advantage especially the sunny Iberian Peninsula. Whilst Germany has the largest number of solar PV installations, Spain is said to have more solar power generation potential as well as a higher EROI than Germany. Pusung (2012) regards Spain as the pinnacle of solar thermal power generation with about 1,037MW installations all expected to go live in 2015

Simelane et al (Eds 2011) explains that Africa is one of the continents that has a huge power deficit with only about 34% of the population having access to power. However, there exists a lot of disparities especially between the rural and the urban as well as the between different countries with over 30 countries in Africa experiencing frequent black outs. In essence, despite Africa having been endowed with many resources for renewable sources of energy, it still lags behind many other developed continents. Sanoh et al (2014) notes that Africa will need to give 5.2GW of new power through to 2015 which signifies a 65% growth against the 2010 figure.

Scanty information is available on the solar energy exploitation in Africa with South Africa and Kenya having the highest recorded data on solar PV systems installations i.e. 11,000 and 3600KWP respectively. Whilst appreciating the potential of solar PV in South Africa especially with the proposed 5,000MW solar park in Upington by 2020, Scholvin (Ed 2015), highlights that one of the key setbacks of solar PV systems growth in South Africa is lack of adequate storage capabilities of solar power.

However, Bundschuh et al (2014) points out that the concessions scheme for rural solar power systems in South Africa denotes one of the ambitious projects for rural power supply which has facilitated installations of more than 13,000 solar PV systems within the 10,000km2 in Kwazulu-Natal. Egypt on the other hand is touted as planning to set up a 300MW solar thermal plant by 2020.Despite all these challenges, Shanahan et al (2013) breathes hope in the solar PV industry in Africa describing it as an industry that is taking off with a 15MW plant in Mauritania and elaborate plans to install a 155MW in Ghana as well as two 50MW solar farms in South Africa. In the publication "Energy Resources in East Africa: Opportunities and Challenges", Otieno et al (2006) describes East Africa region as catching up with the solar PV systems but mainly small stand-alone units as well as solar lanterns which are more concentrated in rural areas.

While comparing the solar PV development of Kenya and Tanzania, Ondraczek (2013) estimates the current installed capacity in Kenya to be around 10MW characterized by over 320,000 solar PV home installations. Kempener et al (2013) paints a picture of a successful commercial activity on solar PV systems with 75% of the solar equipment sold in Kenya being solar electric systems. However, despite this success, the country has been dogged by quality problems in the solar PV system that has led to two testing in 1999 and 2003/2004.This problem has caused a lot of anxiety among the consumers in the market and given that most consumers come from the rural areas, they have not been able to distinguish between the well performing brands from the poor ones. However, in the recent past, the two tests have been able to isolate the poor performing brands leading to them being withdrawn from the market.

Agreeing with Kempener et al (2013), Paron et al (2013) notes that there is a large-scale distribution and indeed penetration of small PV units of between 12 and 15Wp which are mainly the near obsolete technology - amorphous silicon solar panels. However, in the recent times, there has been a proliferation of better technology polycrystalline silicon as well as monocrystalline silicon. According to Bundschuh et al (2014), Kenya has done a lot to streamline the institutions like ERC and KEREA as well as the regulations in regard to solar PV systems. However, more capacity building is required to successfully install large scale solar PV system projects like the 1MW solar PV system installed by SolarCentury at Williamson tea in Kericho or the 600KW Strathmore University project launched in 2014.

1.2 Statement of the Problem

The global energy consumption increases by 2% every year with a significant proportion of it coming from the fossils fuels notes Patwardhan et al (2012).This paints a worrying situation given the devastating increase in greenhouse gas emissions and air pollution emanating from fossil fuels besides the fast diminishing fossils resources.

As a matter of fact, economic progress is measured by the growth rates and therefore any reduction in growth rates is seen as a setback for any economy and this goes further to describe why no economy will grow pegged on a continually declining energy resource such as fossils energy which account for over 80% of the world energy source, notes Goswami (2007).This means that more and more economies around the world are facing increasing pressure to make a transition to renewable energies which are more sustainable.

Campoccia et al (2009) carried out a study with an aim of understanding the supporting measures for the production of solar photovoltaic electrical energy in four European countries. The countries included France, Italy, Germany and Spain. In the findings, the elements of pay-back-period (PBP), the net present value (NPV) and the internal rate of return (IRR) were found to be important determinants in the support of solar PV uptake. These findings are relevant to this study although they do not specifically answer the question of the determinants of the uptake of solar PV in Kenya. The studies thus fall short of issuing satisfactory answers to this research.

In the Kenyan market however, a study carried out by Iarossi (2009) singles out electricity cost and as one of the key hindrances to economic prosperity. However, the study does not clearly show how the cost of electricity can be mitigated through diversified means but generally projects a view that more public investment in electricity generation is crucial.

Anadon et al (2013) while trying to explain the learning's from historical success and failures of solar PV in Kenya focuses more on quality problems brought about by poor quality modules of amorphous Silicon that found their way into the market in the 1990s without addressing other concerns that may have tilted the uptake of Solar PV market as a whole in Kenya.

In a comparative study of Kenya and Tanzania solar PV market, Ondraczek(2013) suggests that the key drivers to solar PV penetration in African market has more to do with affordability, awareness and availability which leaves out the other strong considerations like quality, grid access, and indeed government incentives provided to the solar PV industry. Similar studies carried out by Lay *et al* (2013) in Kenya on renewables in the energy transition tries to explain the choices of lighting fuels in Kenyan households and goes further to explain that awareness, education and income levels are the main determinants of adoption of solar power for household lighting. This however, seems to portray solar PV uptake to be an affluent activity and fails to recognize the role of solar PV to the bigger population especially the rural folks deprived of the grid power.

According to Simiyu, J., Waita, S., Musembi, R., Ogacho, A., & Aduda, B. (2014), total Kenyan electricity supply stands at around 1191MW against a demand of 1490MW which is expected to shot to 2500MW by 2015 with over 51% coming from geothermal and less than 10MW from solar PV sources and only one company making local assembly for solar PV panels i.e. Ubbik East Africa Ltd based in Naivasha. It is therefore surprising that while Kenya falls along the tropics with an enormous potential of solar power, still the market lags behind many other markets that enjoy less insolation hours like Europe, America and Asia.

Indeed according to IEA (2009) only about 55% of the urban population has access to grid power and about 1.5% of the rural population. Additionally Kiplagat et al (2011) explain that the Kenyan market continues to face massive power short fall mainly because of the system loses estimated at about 20% and the fact that the Kenyan market over relies on hydro power which is affected largely by the perennial droughts causing reduction in water levels in power dams. This research therefore seeks to establish the determinants of uptake of solar PV in Kenya in order to provide basic knowledge that will help the growth of solar PV industry whilst helping the economy to have a diversified source of renewable energy.

1.3 Purpose of the study

The study aims to analyze the determinants of the uptake of solar PV by ERC licensed firms in Kenya to help improve the uptake.

1.4 Objectives of the study

The study sought to achieve the following objectives

1. To assess how cost determines uptake of solar photovoltaic in Kenya.
2. Evaluate how quality determines the uptake of solar photovoltaic in Kenya.
3. Assess how government incentives determine the uptake of solar photovoltaic in Kenya.
4. To evaluate how awareness determines the uptake of solar photovoltaic in Kenya
5. To establish how grid access determines the uptake of solar photovoltaic in Kenya.

1.5 Research questions

The research questions that guide this study are as follows:

1. How does the cost determine the uptake of solar photovoltaic in Kenya?
2. How does quality determine the uptake of solar photovoltaic in Kenya?

3. How do government incentives determine the uptake of solar photovoltaic in Kenya?
4. How does awareness determine the uptake of solar photovoltaic in Kenya?
5. How does grid access determine the uptake of solar photovoltaic in Kenya?

1.6Significance of the study

This study is important to the regulatory authorities and policy makers since the outcome of this research will be helpful to not only demystify earlier held notions but also assist the government to know the issues to address in the quest to grow the solar PV industry in the country. At the same time, the outcome of this research will go a long way to influence the route to market for the private sector as it seeks to explain various determinants in an effort to grow the solar PV industry.

1.7Delimitation of study.

The aim of this study is to determine the key factors that contribute to the uptake of solar PV in Kenya. The domain of this study will be the Kenyan market with more focus on the 214 firms licensed by ERC.

1.8Limitations of study

There is lack of adequate documentation of the industry activities since it is a relatively new. However, the researcher intends to seek more knowledge from other developed economies where the industry activities are well documented and endeavor to isolate cases that mirror the local economic activities as well as align those cases with the locally available researches to help appreciate the industry more. Moreover, the researcher seeks to use other related industry data to aid in making accurate judgment and conclusions.
The cost of the research: It requires resources to seek more information as information is not readily available in local libraries. The researcher seeks to subscribe to online libraries where he can review different materials at a minimum cost for more information in relation to this research.

1.9Assumptions of the study

That the respondents will give honest feedback in relation to the various questions.

That the questionnaire used is conclusive in collecting the much required information.
That the respondents will be willing to participate for this research.

1.10Definitions of significant terms in the study

Cost of Solar PV: This is the price of equipment and installation charges

Attitude towards Solar PV: Held beliefs, perceptions and judgments on solar energy

Government incentives: Solar industry support from the government at policy level

Installation skills: Required technical ability to design and install a Solar PV system

Grid access: Closeness of a housing unit to mainstream electricity connectivity

Feed in Tariff: An incentive of offloading the excess power generated from the solar PV systems to the grid

Grid Parity: A point where grid power cost and solar power cost is the same.

Net-metering: A billing system that credits producers for the amount of energy they add to the grid usually as a result of excessive production

Kengen: Kenya Electricity Generating Company Limited

1.11Organization of the study

This study comprises of five chapters with chapter one highlighting the industry background, the statement of the problem, specific problem to be addressed in the study as well as design components.

The second chapter entails the literature reviewed and any other relevant materials in relation to the problem to be addressed by this research while chapter three details the methodology and the procedures utilized in this study for data collection and analysis.
On the other hand, chapter four demonstrates the analysis of the data collected as well as the presentation of the results while chapter five highlights the summary and discussion of the research findings, the implications for practice and areas recommended for future research.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter elaborates the literature reviewed. Under this chapter, different key elements that determine the uptake of the solar PV will be discussed. These elements comprise the cost of the solar PV, quality of solar PV equipments, awareness of solar PV technology, government incentives and grid access to the solar PV industry as key aspects that contribute to the uptake of solar PV. The chapter analysis books, journals, publications and other findings on the determinants of the uptake of solar PV. In addition, this chapter discusses the conceptual framework and definition of variables which informs the knowledge gap.

2.2 Concept of Solar PV

Boxwell (2012) describes solar PV as an exciting concept of shinning the sun rays against photovoltaic solar modules to produce electric energy. Unlike the solar thermal where sunrays are used to generate heat energy to heat fluids, Solar PV systems uses solar modules which comprise of photovoltaic cells that converts the protons from the sun rays into electricity which is used for different applications like lighting, charging batteries, phones and other electrical appliances. Every solar module contains an array of photovoltaic cells which are arranged either in series or parallel. The more the number of cells, the more the amount of electricity generated.

According to Castellano (2010) there are three generations of photovoltaic: the first generation that comprises of a big area, single layer P-N junction diode, the second generation that uses a thin film deposit of semiconductors and the third generation comprise of semiconductors that do not use the old P-N junction technology to separate photogenerated charge carriers. These comprise of devices like photoelectrochemical cells, polymer solar cells and nanocrystal solar cells. However, Carl (2014) highlights that there are generally three types of panels in the market today: Monocrystalline silicon panels which are the most efficient but a bit more expensive with a return electricity of between 14% and 18%, polycrystalline silicon panels which are less efficient than the monocrystalline silicon panels with an electricity return of between 12% and 14% and the traditional amorphous silicon panels which are least efficient with an electricity return of between 5% to 6% and very cheap.

Electricity generated using the solar panels is in direct current mode meaning it can either to be used directly by appliances compatible with direct current (DC loads) or stored in batteries. However, to increase the voltage of the electricity generated, a power inverter is used to convert the direct current to alternating current. This is important especially if the appliances use the alternating current or if the electricity is to be relayed to the grid. Luque& Hegedus (Eds 2011) explains that there are three systems of solar PV: off the grid system which is also referred to as a stand-alone system and comprises of a solar panel or an array of solar panels connected to appliances or storages for home or unit use, the on grid system which comprises of solar panels or an array of solar panels that generates electricity and feeds it to the main grid and the hybrid system which is used in conjunction with another source of power on demand. The on grid system works well where the government provides for feed in tariffs while the off grid systems is a better option for remote areas with no close grid and hybrid system being more used where there is another source of power like town residential houses and is highly favored by net metering. Needless to say that the efficiency of any system is highly influenced by the type of the solar panel, the number of cells, the sizing, the insolation, orientation and tilt, the quality of accessories used in the system and more importantly the installation design and setup skills.

Carl (2014) denotes that the key benefits of using solar electricity especially for home use is the fact that solar electricity is a very quiet source of power, it requires minimal maintenance, increases the value of a home, solar panels have a long life span of above 20 years, saves money and above all, they provide clean renewable energy.

2.3 Theoretical framework

This research seeks to explore the theory of adaptation which is also known as the survival theory as described by great English scientist Charles Darwin in 1830. Charles adaptation theory explains that living beings tend to adapt to their surrounding environments in order to survive else they get extinct. In view of this, it's absolutely clear that the world existent is greatly threatened by the global warming largely attributed to the greenhouse gasses which among other things are as a result of fossils emissions. Therefore, it's imperative that the world over devices ways of adapting to the environment by seeking other sources of energy that do not pose danger to life on earth.

Indeed, Scheer (2001) explains clearly the sun has great power potential than the earth needs and therefore it would be prudent to tap some of this power to drive the world economies. This will not only helps the world mitigate the great destruction caused by fossil emissions but also provide power to drive the world economies. Otherwise as Charles Darwin put it, if organisms don't adapt to the ever changing environment, they die and soon or later, their race become extinct. It's therefore the high time that the world sought to use or adopt the abundance sun resource to power the earth to save the earth from the dangers of extinction. Nevertheless, it is expected that the world transition to clean energy like solar will not come on a silver plate especially given the quasi-institutionalized human culture by the big fossil players who are trending on a smooth path established by decades of infrastructure investments and are hell bent to safeguard their interests by creating rocky path for the renewables.

2.4Cost and uptake of solar PV

Silicon which is heavily used in the manufacture of solar cells is a nontoxic component that is abundantly available in the earth's crust. This further illustrates that it's not only readily available but also almost inexhaustible notes Palz (Edited 2014).Onyeji (2014) explains that the recent advancements in solar PV technologies have led to a massive reduction in the costs associated in the manufacture of solar PV equipments giving Africa an opportunity to enjoy low pricing on these equipments. Its rather surprising that there is a popular view around the African countries including Kenya that generation of electricity from solar PV is much more expensive than the grid, notes Ondraczek (2014).

Indeed according to the 2nd revision of feed in tariff on wind, biomass, small hydro, geothermal, biogas and solar resource generated electricity of December 2012, paying for solar, biomass, biogas, geothermal, small hydro and wind is at $0.12, $0.10,$0.10, $0.088, $0.0825 and $0.11 respectively per Kwh. However, there has been an ongoing debate and indeed research sanctioned by the renewable energy regulatory authority to try and establish the exact cost of solar power as its widely believed that the pricy notion of solar PV is more based on perception and historical academic papers than recent facts given the fast declining prices of solar modules. Its worthy noting that while module prices stayed at $3.5 to $4.0 per Wp between 2004 and 2008, prices of the modules had fallen to as low as $1 in 2012 and could be much lower by 2015 notes Simiyu *et al* (2014). On the other hand, Jacobs R. (2014) add that even though the cost of solar PV is not depended on modules alone, the LCOE of solar PV suggests that the cost has gone down by 50% since 2009 to as little as $0.16/ kWh for the thin film based solar PV technologies. Ondraczek (2014) indicates that based on the actual technological costs and the solar resource in Kenya, the levelized cost of electricity from the solar PV was around $0.21/kWh in 2011 and about $0.8/kWh in 2013. This submits that the levelized cost of electricity in the grid connected solar PV systems may be much lower than that of the conventional power plants further suggesting that the policy makers may be mistaken to perceive solar power as an expensive venture rather than a feasible solution to diversified power source for developing economies.

Boxwell (2012).Observes that with the fast declining cost of solar power emanating from improved technology; it's likely that by 2015 solar will be the cheapest type of electricity generator. Similarly, Seba (2010) argues that one of the biggest fallacy in the solar PV debate is that of grid parity. Seba (2010), goes further to explain that most of the peddlers of this argument fail to recognize the fact that solar power cost is highly influenced by insolation and indeed grid parity has been achieved in areas like Hawaii presenting a case that in areas of high insolation and relatively high grid electricity costs especially the tropics along the equator it's possible to achieve grid parity with today's solar technology. In Hawaii while the cost of solar power is 20cents / kWh, the grid electricity is between 30 to 40 cents /kWh! Wolfe (2013) agrees with Seba (2010), that the media discussion cannot be pegged on grid parity only while over 2.5billion people according to UNESCO have no access to grid power yet there exists an opportunity to get power from solar PV systems.

On the other hand, Deambi (2011) appreciates that the solar energy generated during the day needs expensive batteries for storage and therefore new and inexpensive technologies are required to bring down the cost of storage batteries either by adopting the light weight electrochemical batteries or super capacitors for electrostatic storage. According to Deambi (2011) the cost of solar panels has consistently been declining over the years with BIPV costs falling by 50% between 2005 and 2010 and a further expected 50% by 2020. At the same time the efficiency of crystalline silicon cells as registered an impressive increase from 14.5 in 2004 to 17.5 in 2010 with a great room for future improvements.

The most encouraging aspect in most researches has been that with the increased economies of scale and continuous improvement of the solar technologies the costs are likely to keep going down in the foreseeable future breathing more life into the solar revolution around the world. Indeed Jacobs (2014) predicts that by 2015, the solar power cost including the set-up installation and panels will be at par with the cost of fossils energy in most major cities and much lower and more efficient than fossil energy by 2025.Indeed, there has been excitement in the Kenyan market in the recent past with the enactment of PPP act in 2012 which provided for FIT with a PPA at $0.12 per kWh for solar Energy. This has encouraged both entrepreneurs and investors to look at the potential in the solar PV which has resulted to increased investment in the solar PV industry. Nevertheless, lack of net metering policy in the Kenyan market has tended to discourage the small household users who would otherwise consider it a big benefit by avoiding the expensive storage batteries and getting some credits in return.

2.5 Quality and uptake of solar PV

Quality is an integral part of every brand as it delivers the value and the trust of a products innovation to the consumers. Indeed quality is achieved through rigorous checks by the quality control under different conditions to have a formed view on the suitability of a product. Anadon *et al* (2013) notes that in Kenyan PV market, equipments quality has been achieved through a combination of strategies in public policy like the Kenya bureau of standards and market institutions like the quality control assurances, testing, supplier credibility as well as end user confidence. The key attributes of measure of a solar PV quality revolves around the rated power output as well as the durability and longevity of the product besides the conformance to local rules and regulations.

In his publication "Energy Technology Innovation: Learning from Historical Successes and Failures" Kempener (2013)describes the 90's as the years faced with great negativity of the solar PV industry caused by faulty solar panels that found their way into the Kenyan market. This greatly influenced to build up a perception of the local consumers especially the rural folks who have no connection to the grid that the solar panels "never works" as the panels terribly failed to meet the minimum expectations of the consumers. Anadon et al (2013) attributes most of the quality problems associated with the 90's to lack of capability to detect or measure quality among the Kenyan authorities and thus the authority had to rely on the foreign help to curb the proliferation of substandard solar modules in the market. Indeed it took independent testing of panels in 1999 notes Patwardhan *et al* (2012) to weed out the underperforming suppliers and brands.

Despite the notable commercial achievement of solar PV in Kenya by 2004, Onyeji (2014), describes the year 2004 as one that rekindled the memories of poor quality of the 90's as a result of spirited media claims of substandard solar PV modules amongst competitors blaming each other by putting up numerous newspaper advertisements. This sparked a heated debate about solar PV modules quality, the consumer rights and the ethics of negative advertising.

Thompson (2003) also highlights that Solar PV systems quality has overly been affected by the lack of skilled labour for designing and implementing the system as well as inadequate knowledge among the vendors which negatively affects their ability to advice their consumers appropriately. Simiyu *et al* (2014) estimates that there are around 1000 installers around the Kenyan market of which only about 200 are well trained to install the solar PV system meaning that over 80% of the installers are either semi trained or ill trained to handle installation which goes further to affect quality of installation and by extension the performance of the systems. Indeed Martin (2010) while conducting a study on the penetration of renewable energy in the new markets estimates that almost a third of the installed solar PV systems in Kenya aren't fully operational due to failure of regulatory authorities' enforcement of installation and design standard besides the poor quality of the components used.

In the recent past though, much improvement has been made through formation of KEREA which is a peer association including the renewable energy participants in the local market as well as strengthening of ERC which manages the affairs of energy in Kenya and which facilitated the renewable energy act of 2012 that seeks to enforce the quality assurances through certification of importers, contractors as well as installers in the market besides carrying out energy audits. Indeed, there has been a concerted effort by various training institutions among them private colleges, government tertiary colleges and Universities developing a curriculum to curb the deteriorating installation quality by providing formal training to this group of technicians and ERC putting in place some licensing mechanism for qualified technicians who pass the set tests. However, more need to be done by the regulator to make sure that all the installations are up to the required standards and indeed the components are of the required quality.

2.6 Government incentives and uptake of solar PV

Most governments around the world especially in Europe where solar PV industry has experienced rapid growth, there have been one underlying factor that has greatly influenced this growth; the government incentives notes Jacobs (2014).Agreeing with Jacob (2014), Doris (2015) explains that many governments around the world especially in Europe and America are giving financial incentives to companies working on developing the solar PV infrastructure namely the contractors and vendors as well as the consumers who buy them. This is in an effort to stimulate more demand and increase the penetration of the solar electricity offering clean energy. United States International

Trade Commission (2005) in an effort to unravel the global markets for renewable energy services as well as the issues related to the international trade of these services notes that the demand for renewable energy services are greatly influenced by the government policies and especially those related to incentives that make the product affordable. The report argues that incentives do not only increase penetration but also increase the awareness of the product.

Interestingly though, Wilkins (2010) isolates Kenya as one of the few economies in the world where solar power sector grew with no or less support from the government. Wilkins (2010) observes that the solar PV industry in Kenya has largely grown along the commercial line with some support from the donor community through the NGO's. This explains why the Kenyan market has for a long time been confined to 10 to 30Watts solar PV systems which the consumers could afford even when the demand was much higher notes Martin (2010). However, in the recent past, there has been a government drive to power all primary schools in the country through the rural electrification programs which have seen the government rely on the solar PV to power those primary schools off the grid line. Nevertheless, according to Palz (Edited 2014) the governments in the developing economies and especially in Kenya have zero rated the solar PV panels. However, other accessories like the storage batteries and lighting bulbs have remained under the tax structure more because of their multiple uses and therefore it's technically not right to say that the solar PV systems are zero rated in Kenya.

According to Martin (2010), the Kenyan government through the policy makers needs to encourage the financial institutions especially the micro finance institutions to give more credit lines to the solar PV systems consumers to encourage more uptake of solar PV power. He further proposes that the government can consider using grants to attract the micro financing institutions although he strongly advises against free-for- service program as it has been a big failure else ware in the developing economies for example a case of South Africa. More importantly is the consideration raised by Ondraczek (2014) to increase the duty exemptions on not only the solar PV modules but also the accessories like inverters which are relatively pricy increasing the cost of solar PV systems.

On the other hand, KEREA members have petitioned to the government to intervene on the PPA rate to have it reviewed upward otherwise the current $0.12 per kWh rate offers minimal return to investors who are willing to invest in the industry besides the government should consider offering tax holidays to investors who are willing to set up local operations for both manufacture and assembly of solar PV systems. Besides, there have been intense lobbying for adoption of net metering by the regulator and this is expected to be a game changer in the industry as it marks the introduction of REC's especially to the small home user. This will go a long way to increase the uptake of the solar PV.

2.7Awareness and uptake of solar PV

While the technology has been with us for decades now, solar PV technology is still perceived as a new technology largely because of the low awareness of the application of solar PV systems, notes Pode& Diouf (2011). This has been a big hindrance to the penetration of the technology which Leggett (2014) blames on the quasi-institutionalized human culture championed by the utility and fossil energy bigwigs to disrupt technologies and innovations that pose a threat their businesses by romanticizing the big things; nuclear, oil and gas often overshadowing the voice of the renewables which in essence curtails the mass awareness especially on the benefits which mitigate the dangers emanating from fossil energy.

In Kenya, the set back of the 90's and 2004 occasioned by bad publicity of the proliferation of poor quality solar PV panels deeply affected the perception and trust of solar PV as an alternative to main grid which led to many losing interest in the industry, notes Patwardhan *et al* (2012). On the other hand, a big percentage of the local population especially from the rural areas have a formed view that the solar energy is mainly for drying items and food but not necessarily for generation of power to which is a reserve of the grid power because of lack of good exposure as well as education of the potential of sun rays into generations of power through the PV panels. Indeed Simiyu (2013) notes that the fact that many cultures across the country are used to using firewood as a means for generation of heat energy and kerosene for lighting using small lamps has helped inform the rural culture with many Kenyans especially in the rural areas viewing the solar PV as very foreign and hence not trusting it so much to handle the loads they use in their homes.

Indeed the Kenya energy policy, law and regulation handbook volume 1 on strategic information and regulations identifies lack of awareness on the potential, prospects and economic benefits offered by the solar power as one of the challenges that need to be addressed in the policy and strategies framework in order to encourage increased use of solar PV systems in Kenya. Hankins (1995) observes that in order to increase the awareness of the solar PV industry, a concerted effort should be established between the public sector through formulation of policies that encourage the uptake hence increasing awareness and the private sector who sell the equipments and build the infrastructure for adoption of the solar PV systems. This coupled with media advertisements, training and technical assistance will go a long way to increase the awareness in the otherwise revolutionary solar PV industry, adds Bhandari (2010).

2.8 Grid access and uptake of solar PV

According to the IEA (2010) only 16% of the Kenyan population has a connection to electric power meaning over 33million Kenyans lack access to electric power. While about 55% of the urban population has access to grid power, IEA (2009) estimates that only 1.5% of the rural population have access to grid power.

According to Wilkins (2010), 70% of the Kenya population lives in the rural areas with little or no access to grid power. Simiyu et al (2014) seems to agree with IEA (2010) that only about 15% of the Kenyan population is powered by the grid power showing that majority of the Kenyan population lacks grid connection. However, a surprising phenomenon is projected by Bhattacharyya (2012) who citing a study carried out by Abdullah and Jeanty (2011) claims that the rural based homes are more willing to pay more for a grid connection than solar PV installation and that they prefer to make monthly payments for the units consumed unlike the lumpsum payment for solar PV system installation.

Ironically though, even with the frequent power outages from the grid connections, it seems that majority of the Kenyan population mainly due to lack of awareness of the potential and indeed true cost of solar PV systems consider grid access as a more reliable source of power and would rather pay an arm and a leg to access the grid power with less or no consideration of the solar PV power. In fact, once a household gets access to grid power, it seems that the thought of alternative source of power is never a consideration. However, Halff et al (2014) suggests that with more awareness and encouragement of net metering, there is a high chance of the population with access to the grid power considering the solar PV systems.

2.9Conceptual Framework

The conceptual framework shown in figure 1below is a schematic diagram which illustrates the relationship between the dependent variable which is the uptake of the sola PV and the independent variables which are cost, quality, government incentives, awareness and grid access.

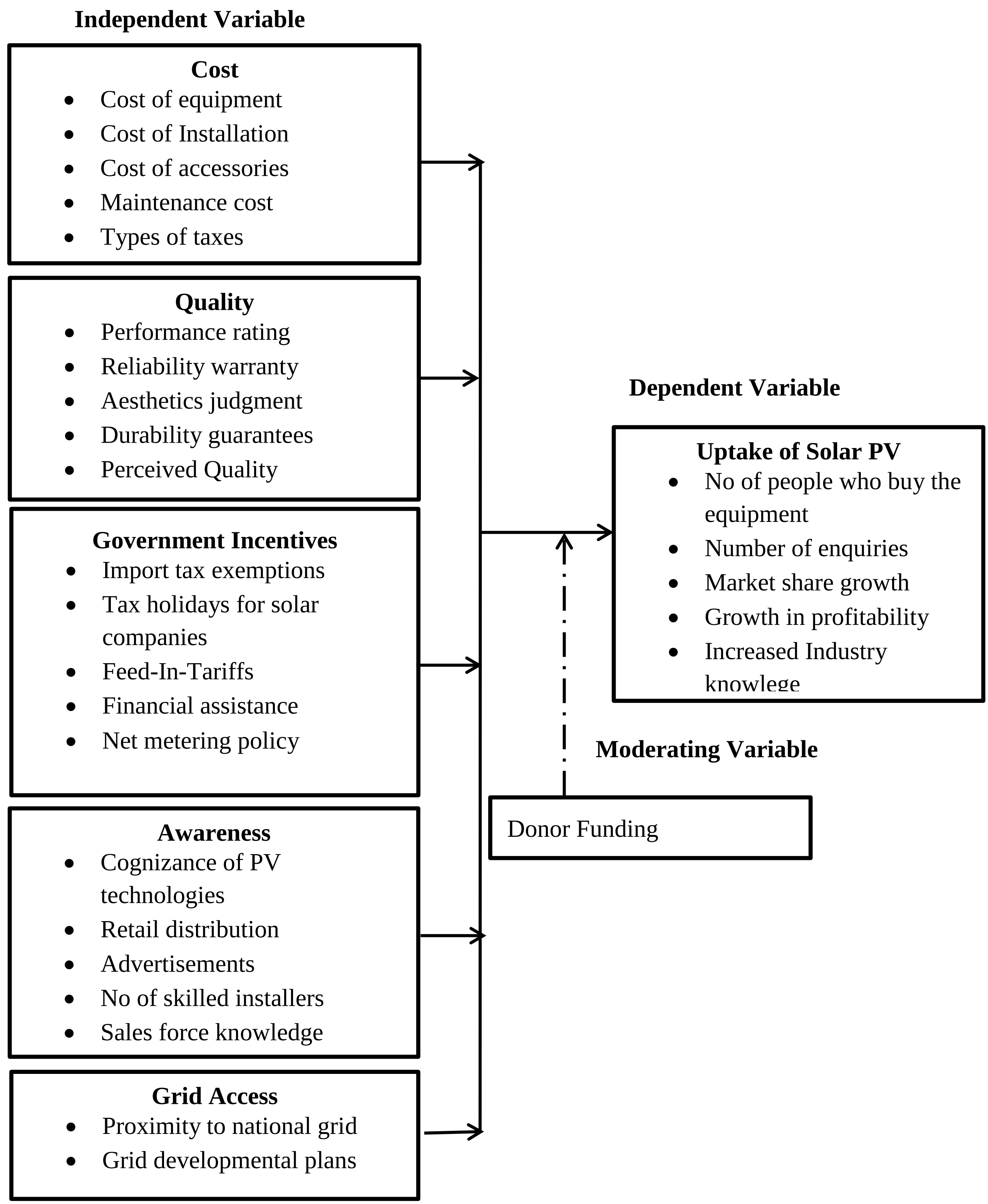

Figure 1: Conceptual Framework on the relationship of variables

Interrelationship between Variables

The price of solar PV systems forms a critical consideration in any buying process and therefore very high equipment costs and hefty installations charges will definitely discourage the procurement of the solar PV systems and therefore contribute to low uptake of the same. Similarly, affordable pricing and installation charge will encourage the uptake as it is deemed good value for money. On the other hand quality either perceived or real helps to build conceptions and perceptions about a product and indeed the brand which influences the uptake decisions. A perceived good quality encourages the uptake while the low quality may negatively impact on the uptake.

Critical to Solar PV uptake is the government support of the industry. Countries where Solar PV uptake has been a great success notably Germany, Italy, Spain, Japan and USA shows that there exists a correlation between government intervention through incentives and the solar PV growth. Government incentives offer the industry the impetus to grow therefore enhancing availability of equipments and indeed influencing the uptake.

Similarly, the awareness level of the consumers which is greatly influenced by educational level affects the uptake of solar PV. Ondraczek (2014) observed that solar PV grows in the Kenyan market in clusters and is greatly influenced by awareness. This explains why areas where there are old solar PV systems, one tends to see more and more of the same mushrooming in the area unlike the areas where none existed.

Needless to say, lack of grid power tends to influence the uptake of solar PV given the need for electricity in homes. In areas with available grid, the uptake of solar PV tends to be lower since there is no policy on net metering and therefore many homes see this as a duplication of power source than a complementary.

2.10Research gap

Solar PV being a relatively young industry in Kenya, there hasn’t been a lot of documentation on the industry. Conversely, while there has been some research on key determinants, Kenyan government incentives have not been covered. This research therefore sought to delve deeper to establish how government incentives determine the uptake of solar PV industry.

2.11 Summary of literature review

The literature review highlights that there is need for further research on various determinants of the solar PV uptake. Indeed, the literature reviewed clearly shows that there are widespread misconceptions especially on the cost as well as mixed feelings on the government support.

On the other hand it's clear that there is less awareness on the potential of solar PV systems and more resources would be dedicated to create this awareness. Indeed, no author claims completeness of the determinants of solar PV uptake and therefore more research is necessary in order to ascertain the critical considerations to uptake of solar PV in Kenya especially given the renewed excitement around the renewable energy in Kenya.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the methods used to obtain, analyze and present data have been discussed. Under the chapter, there are five sections which include the research design, target population, sample size and the sampling process and the data analysis method used in this research.

3.2 Research Design

This study used descriptive research design. Descriptive research design, according to the definition by Kothari (2009) includes the use of surveys and fact finding techniques of different kinds. This type of research tries to explain things the way they exist. Here, the researcher has no control over the behaviour of the variables but rather reports what is happening to the variables as they are. Descriptive design is widely used to obtain information concerning a phenomenon to explain what exists in regards to variables in a given situation. It allows the researcher to describe record, analyze and report conditions that exist. Descriptive research is therefore the best research design to use when researcher wants to gain deeper understanding of a phenomenon. Mitchell (2012) explains that descriptive research involves gathering information or data that describe events and then organizes, tabulates, depicts, and describes the information collected.

Gravetter (2015) further explains that descriptive research design comprises of three types: observation research, survey research and case study research. This research therefore used the survey research design as its best suited to address the research problem. This is due to the fact that besides explaining the events as they are without altering the variables, survey research is easier to administer and cost effective.

3.3 Target population

Ott& Longnecker (1993) refers to target population as a collection of objects to which the conclusions of the study applies. The target population of this research comprised of the company heads, sales managers and sales engineers in the 214 solar PV firms registered by the ERC. These firms included the vendors and contractors in the solar PV industry. This research obtained the sampling frame or the source list from the ERC website with the full addresses of the registered firms. This in essence helped the researcher to get credible information since only the licensed firms were surveyed in this research using a census method.

3.3.1 Sample size

Sampling is the process of obtaining information about the target population by studying a selected number of units to represent the target population (Kothari 2007). A sample is a selected number of units whose characteristics are powerful enough to generalize the characteristics of the target population under review (Singh& Mangat, 1996). This research used a census since according to Mugenda and Mugenda (2003), it is prudent to use a census when the respondents under study are within a reasonable number and can be easily accessed.

3.3.2 Sampling procedure

Sampling procedures are methods used to select the units to be studied from the target population to be included in the sample. It is therefore important to pay attention to the selection of the sample as this goes to a big extent to define the credibility and indeed the conclusions of the characteristics of the target population. According to Ryan (2013) it is prudent in research to have a sample size of not less than 30% of the target population.

This research used a census survey to study the respondents which were within the scope of management as the number wasn't too big and was easily accessible since this information is available at the ERC's website with a full list and contacts of all registered firms that deal with solar PV systems.

The respondents included the sales engineers, sales managers and company head of the 214 solar PV registered firms in Kenya.

3.4Research instruments

Data can be classified as primary or secondary and therefore, it's imperative that the researcher decides on the kind of data required before choosing the data collection method for his research explains Mitchell (2012). In this case, the researcher chose survey research; using a questionnaire survey where the respondents get to read the questions and then write down their responses. According to Kothari (2011), this method is fast becoming popular among the business and economic surveys because of, among other things, its low cost. This is true especially when the population is large and dispersedly distributed. It is free from bias of the interviewer and it provides adequate time for respondents to give well thought out feedbacks. The respondents that are not easily accessible can be reached conveniently and the researcher can easily use large samples therefore making the research more dependable and reliable. However, the critics of this method argue that there is low return of the filled up questionnaires. As well the control of the questionnaire may be lost once the questionnaire has been sent. It is a bit difficult to know whether the willing respondents are the true representative and that the method is one of the slowest of all. The researcher administered the questionnaires via emails and also made follow ups by phone calls as well as emails to the firms under study. However, there were a lot of delays from the firms as many viewed the study as not helpful to them in terms of turnovers since it wasn't going to be shared with them and they had little control of the same.

3.5 Piloting the instruments

Before using the data collection instruments, the researcher subjected them to a pilot test. This ensured that the tools are valid as the feedback on any loose ends was addressed before the collection instruments were sent out to the respondents. This helped remove any ambiguity and unnecessary information or questions from the questionnaires. The piloting was carried out by giving the questionnaires to peers for review. Before using any instruments for factual data collection, it is important to ensure that they function in the way they are intended to. This is what piloting entails Gass (2000). The objective of piloting was to ensure that the instruments used were free from vagueness and that the data generated was meaningfully analyzed in relation to the listed research questions and hypotheses. It's always advisable to pilot using participants in the target population as well as experts in the specific industry to make sure that the instrument reflects their perceptions. After piloting, some adjustments were made in order to address specific areas of concern using the information gleaned from piloting to make the questionnaire more accurate to gather the correct information as recommended by Paltridge and Phakiti (2010).

3.5.1Validity of the instruments

Mugenda and Mugenda (1999), defines validity as the accuracy and indeed meaningfulness of inferences which are based on the research results of the study. Validity refers to the appropriateness, meaningfulness and, usefulness of evidence that is used to support the interpretations (Cooper & Schindler, 2003). Validity is therefore the degree to which results obtained from analysis of the data collected actually represent the phenomenon under study. It is correctness and reasonability of the data collected. The validity and clarity of the questionnaires were tested before mailing them by use of peers who were also conducting research from our institution and professionals in the research industry. On the other hand, the researcher ran a pilot survey using at five people in the solar PV industry whose feedback was very instrumental in making the adjustments to the final questionnaire to be mailed out to the respondents.

3.5.2 Reliability of the instruments

Instrument reliability is a very critical element of any research. Reliability is an inspection of the consistency between a set of independent observations that are substitutable. Reliability is the extent to which results are unswerving over time and are accurately representative of the total population of a study; the results of a study are believed to be reliable if they are reproducible under similar methodology Nahid (2003).

Reliability can be defined as the degree to which a questionnaire, test, observation or any other measurement procedure yields the same repeated trials; it is the stability or steadiness of scores over time Michael, (2010). Mugenda and Mugenda (1999), defines reliability as a measure of the degree to which a research instruments yields unswerving results after repeated trials. Berg (1998) explains that, the use of consistent and systematic line of questions for even unanticipated areas in particularly important for reliability and for possible replication of a study.

Therefore the questionnaires were subjected to review of peers both in the institution as well as in the solar photovoltaic systems' and project management field in general and feedback considered in the adjustments of the questionnaires before mailing to the respondents. This ensured that ambiguity had been removed and any areas that were not consistent with the study were expunged after peer review.

3.6 Data collection procedure

Data collection procedure describes how the researcher intends to collect the data (Groves 2011).The researcher upon receiving a clearance letter from the University applied and secured a permit from the National Commission of Science Technology and Innovation to carry out the research. The researcher then developed a list of the target population which was the sample size since the researcher opted for a census survey. With the clear contact details available on the ERC website, the researcher then mail out the introductory letter and questionnaires to the respondents. This was followed by a follow up call two days later to the respondents to notify them of the mailed questionnaire and a brief explanation. In cases where there were delays in response from the respondent, the researcher made follow up calls to remind the respondent of the delays and sought to have their feedback. However, not all the respondents mailed back the questionnaires.

3.7 Data analysis technique

The data generated using the questions in the questionnaires was carefully scrutinized for completeness, accuracy and uniformity and then coded for ease of analysis. The researcher used measures of central tendency for this analysis. The arithmetic mean was used to evaluate the response of the firms to each of the tested objective. Arithmetic mean is computed by dividing the total sum of objects by their frequency of occurrence (Osborn2005). In order to understand the variation in the responses given by each company, standard deviation was be used. Standard deviation is the square root of the variance (Black, 2011).

3.8 Ethical consideration

The Belmont Report (1979) highlights that there are three pertinent basic principles to the ethics of research involving human subjects, which are; respect of persons, beneficence and justice. Agreeing with this report, Babbie (2013) insists that consent of the participants is indeed crucial and the same cannot be achieved through coercion but rather voluntary. Therefore, care must be taken to make sure the respondent are treated with the principles of respect of person, beneficence, and justice were informed through consent, confidentiality, anonymity and, the participant's right to privacy (Miller et al 2012). To enhance ethics in this research, the researcher made sure that the names of the participants and the organizations they work for were not recorded nor were they a requirement in the questionnaires. At the same time, all the questionnaires were downloaded from the emails and stored in one folder without reference to the respondents and were given numeric tags. On the other hand, the respondents were clearly guided in the email not to indicate their firms' names or individual names in the questionnaires. However, there were cases where the respondents indicated the company names, in those cases the questionnaires were destroyed and a fresh questionnaire was sent to the respondent explaining the inadequacy of the earlier received questionnaire and giving clear instructions on how to fill up the questionnaire to be valid for the research being undertaken. At the same time, the researcher sought the consent of the participant by explaining the importance of the study to policy makers and indeed the industry fraternity which helped the respondents to give feedback without any coercion or inducement.

3.9 Operationalization of variables

This is a table that shows the variables and their operational indicators.

Objectives	**Variables**	**Type of variable**	**Indicators**	**Method of data collection**	**Data collection tools**	**Data Analysis Technique**
To assess how cost of equipment and installation determines the uptake of solar PV in Kenya	Cost	Independent	1.Cost of equipment 2.Cost of Installation 3.Cost of accessories 3.Cost of maintenance 4.Taxes and levies	Administering questionnaires	Questionnaire	Descriptive
Evaluate how quality of equipments determines the uptake of solar PV in Kenya.	Quality	Independent	1. Performance 2. Reliability 3. Aesthetics 4. Durability 5. Perceived quality	Administering questionnaires	Questionnaire	Descriptive
Assess how government incentives determine the uptake of solar PV in Kenya	Government incentives	Independent	1.Import tax exemptions 2.Tax holidays for solar companies 3. FIT 4.Financial assistance	Administering questionnaires	Questionnaire	Descriptive

			5. Net metering			
To Evaluate how awareness determines the uptake of solar PV in Kenya	Awarenes s	Independent	1.Cognizance of PV technologies 2. Retail distribution 3. Advertisements 4. No of skilled installers 5. Sales force knowledge.	Administering questionnaires	Questionnaire	Descriptive
To establish how grid access determines the uptake of solar PV in Kenya	Grid access	Independent	1.Proximity to the national grid	Administering questionnaires	Questionnaire	Descriptive
To evaluate how uptake of solar PV is influenced by cost, quality, government incentives, awareness and grid access,	Uptake of Solar PV	Dependent	1.No of people who buy the equipment 2.Number of enquiries	Administering questionnaires	Questionnaire	Descriptive

CHAPTER FOUR
DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter covers data analysis, presentation, interpretation and discussions of the data collected from the solar photovoltaic registered firms in Kenya. Under this chapter, there are nine sections which include the questionnaire return rate, position of respondents in the organizations, the number of years the firm has been in operations, years of experience of the respondents in the industry, cost and uptake of solar PV, quality and uptake of solar PV, awareness and uptake of solar PV, government incentives and uptake of solar PV as well as grid access and uptake of solar PV.

4.1.1 Questionnaire return rate

Out of the 214 targeted subjects of study, 134 filled and returned their questionnaires. This represented 62.61 % overall response rate. According to Babbie, E. (2013), the acceptable percentage rate varies with the nature and focus of the research but overly above 50% return rate is generally acceptable. The response rates for each stratum have been illustrated in Table 4.1

Table 4.1: Questionnaire return rate

Firm Categories	Questionnaires administered	Questionnaires Returned	Response Rate (%)
Importers and Distributors	124	77	62.1
Contractors	90	57	63.3

This rate was considered satisfactory for analysis. The questionnaire responses were broken down into manageable categories, coded and thereafter quantitatively analyzed to get insights and make inferences. These were subsequently presented in tables, graphs and in equation forms.

4.1.2 Position of the Respondents in their Organizations

The research sought to understand the positions of the people that responded to the questionnaires. The response is indicated in Table 4.2 below.

Table 4.2: Position distribution of the respondents

Firm Categories	Company Heads	Sales Engineer	Sales Manager	Total
Importers and Distributors	17 (22 %)	41 (53 %)	19 (25 %)	77 (100 %)
Contractors	6 (10 %)	25 (44 %)	26 (46 %)	57 (100 %)

The questionnaire asked the respondents to indicate their positions in the company. The options included the sales engineers, sales manager and company head. This question was considered important because the position of the respondents can determine their understanding of the market dynamics of solar photovoltaic systems.

4.1.3 The number of years respondents have been in operation

During the study, the respondents were asked to indicate the number of years that they have been operating. Table 4.3 below shows a summary of the response.

Table 4.3: The number of years respondents have been in operation

	Time that the Companies have been in operation		
Firm Categories	**Below 1 Year**	**Between 1 and 5 Years**	**More than 5 Years**
Importers and Distributors (%)	23	41	36
Contractors (%)	15	46	39
Mean	**19**	**43.5**	**37.5**

The questionnaire tested the years of operation in three categories. They included less than one year, between one and five years and more than five years. The answers were categorized in the two strata. The question that tested the number of years they have been in operation. The computed values show the percentage number of companies that have been operating in each category of years indicated.

From Table 4.3, it is clear that most of the companies, 43.5 %, have been in operation between 1 and 5 years. This indicates that they have had experience in implementation of projects over a period of between 1 and 5 years. This is enough span of time for most of the respondents to give well informed feedback in the study. It's also important to note that 37.5% of the companies have been in operation for more than 5years and only 19% have been in operation for less than 1 year building more credibility to the information provided as majority of the organization are deemed experienced in the industry.

4.1.4 The number of years that the respondents have worked in solar photovoltaic systems industry

The researcher attempted to find out the number of years that the respondents had been working in the solar photovoltaic industry. Table 4.4 show a summary of the response of the two strata to the question that tested the number of years they have been working in the industry.

Table 4.4: The years of experience of the respondents in the industry

	The years of experience of the respondents in the industry		
Firm Categories	**Below 1 Year**	**Between 1 and 5 Years**	**More than 5 Years**
Importers and Distributors (%)	13	38	49
Contractors (%)	12	35	53
Mean (%)	**12.5**	**36.5**	**51**

The experience of the respondents is essential when collecting data about the uptake of solar photovoltaic systems. The respondents were asked the number of years that they have worked in the industry. The questionnaire tested the years of experience in three categories. They included less than one year, between one and five years and more than five years. The answers were categorized in the two strata. The computed values show the percentage number of respondents with their experience in each category of years indicated.

From the results, the research found out that most of the respondents, 51 %, had been in the solar photovoltaic system industry for more than 5 years. This indicates that they have good background knowledge of the operation of the industry. Still, it shows that the players retain their employees or they employ more experienced employees in the industry.

4.2 Determinants of the uptake of solar photovoltaic systems in Kenya

The study tested four variables to determine if they affected the uptake of solar photovoltaic systems. The variables included cost, quality, government incentives, awareness and grid access. The results were analyzed for each variable. They were displayed in tabular and graphical forms and explained using prose format.

4.2.1 Cost and uptake of solar Photovoltaics

In the study, the respondents were given five parameters that relate to the cost of the solar photovoltaic system and uptake and then requested to rank them with regard to their contribution to the uptake of the systems. The responses from all the subjects were compiled and presented as shown in Table 4.5

Table 4.5: The effect of cost on uptake of solar PV systems

Cost Determinants	Percentage Score from Contractors	Percentage Score from Importers and Distributors	Mean Percentage Score
The cost of solar PV panels	50	65	57.5
The cost of solar PV accessories	54	58	56
The installation charges	69	65	67
Maintenance cost of the solar PV systems	54	67	60.5
Taxes levied on the solar PV products	42	58	50.5
Mean	**53.8**	**62.6**	**58.2**
Standard Deviation	**9.808**	**4.278**	

The cost of the system in terms of cost of solar PV panels cost of solar PV accessories, installation charges, maintenance cost of the solar PV systems and the taxes levied on the solar PV products were evaluated. The respondents were requested to evaluate these factors on a scale of 1 to 5. One was allocated the highest weight and five was allocated the lightest weight. In the analysis, scale number 1 was rated at 80 % two was 64%, three was 48%, four was 32% while scale number 5 was rated at 16 %. The scores from each respondent for each variable were added and then averaged to come up with the overall points.

On average, the respondents rated the effect of cost on the uptake of solar PV systems at 58.2 %. This is more than 50 % and according to the percentage scores given to the ratings; this has an above average score. However, disparities in the scores were noted as shown in Table 4.5. The scores rated by the solar PV contractors are different from the scores rated by the importers and distributors. Generally, the contractors thought the effect of cost was less, when compared to the views of the importers and distributors. Whereas the contractors scored the effect of this variable at 53.8 %, the importers and distributors scored it at 62.6 %. This could imply that the two different stakeholders incur different costs when dealing with the solar PV systems. It's possible that the importers and distributors consider the cost of money especially given the rate of stock turn around while the contractors mainly procure when they have a project to service. As well, it could mean that most of costs involved in solar PV systems are not related to the installation of the same. On the other hand, the importers and distributors could be incurring more expense for marketing, awareness creation as well as distribution or logistical costs. From the standard deviation values, it can be deduced that the dataset from the importers and distributors has a narrower spread of measurements around the mean and therefore has comparatively fewer outlier values than the data set from the contractors.

The standard deviation for the means from the contractors is 9.808 while that of the importers was 4.278. This means that the values from contractors lie far away from the mean when compared to those from the importers and the vendors. In essence, it shows that the distributors and importers have a better understanding of the cost element and that their costs are more or less uniform. On the other hand, the contractors could be incurring different especially given the disparity on the cost of installation charges which might imply that they change different charges and their costing may not be uniform. The different standard deviations between the scores for the contractors and that of the importers and manufacturers also show that the cost implications of solar photovoltaic system uptakes are more varied to the contractors than to the importers. Whereas the importation and vending costs could be limited to factors like taxation and price competition, the contracting aspect of solar photovoltaic systems is subjected to multivariate factors which differ from one contractor to another. One contractor can charge double the price of another contractor, depending on his expertise in the field and his negotiation skills. These inherent differences in the cost aspect of contracting and importing come out clearly in the standard deviations recorded from the study. Still, from the standard deviations, it can be thought that the respondents from the contractors' side do not have adequate knowledge about the cost aspect of solar photovoltaic system. When the respondents are not well versed with the subject under discussion, there may be larger standard deviation values.

The elements that inform the cost of solar PV system uptake also scored differently. In the analysis, it was found that the effect of taxes on solar PV system scored the lowest, at 50.5 %. The charges of installing the system were rated to have the highest effect on the uptake of solar PV systems, at 67 % this could mean that there are a few certified technicians to design and install the solar PV systems and therefore since the have an upper hand on the demand, they are able to charge high price which increases the cost of the uptake of the solar PV. Furthermore, the cost of maintaining the systems came second in the magnitude of its effect on uptake of the solar PV systems. The Solar PV systems comprise mainly of solar panels that require less maintenance simply because they are largely immobile, nevertheless, it is possible that the high cost in maintenance comes from the storage maintenance that involves batteries which could be expensive. The third was the cost of the panels and the fourth was the cost of the accessories of the solar PV system.

The findings of this study are congruent with the findings of Miler et al (2014) in a study that was carried out in New Zealand. This study was aimed at finding the variables that influenced the uptake of solar photovoltaic systems in the country. These findings stated that the cost of installing solar photovoltaic systems was declining. However, it was stated that the accuracy of the rate of decline was not easy to ascertain. The study suggested that the reduction in the cost of installing the solar photovoltaic will lead to increase in popularity of the systems in New Zealand. The findings of this study largely agree with the findings of Miller et al (2014). The cost savings of use of solar photovoltaic power are thus either an attractive or repulsive factors in the uptake of the solar energy. These findings are also in agreement with Muhammad et al' (2013) findings which stated that if the cost of installation of solar photovoltaic systems could reduce, then the uptake of the solar home systems would increase in the United Kingdom. In Argentina, cost was found to be an obstacle to uptake of solar photovoltaic system. As a result, the government came up with interventions that lowered the costs and improved the uptake of the system Alazraki & Haselip, (2007).

Findings from studies by Wamukonya (2007) can also be used to explain the findings of this research. The author stated that cost was one of the impediments of the adoption of solar home systems in Africa. Even though solar home systems were said t be cost effective, the study explains, they did not largely meet the expectations of the governments in terms of cutting of energy costs. As such, similar to the findings of this research, it can be ascertained that the cost function is an important indicator in the adoption of the solar photovoltaic systems in the country.

4.2.2 Quality of the solar PV equipments and the uptake of solar PV systems

The research postulated that the quality of the available solar PV products affected the uptake of solar PV systems. Below Table 4.6 shows the data collected against the five parameters.

Table 4.6: The Effect of quality of solar PV products on uptake of solar PV systems

Quality Determinants	Percentage Score from Contractors	Percentage Score from Importers and Distributors	Mean Percentage Score
Rated performance of the solar PV product	59	44	51.5
Reliability of the solar PV product	61	75	68
Aesthetics of the solar PV product	42	57	49.5
Durability of the product as covered by warranty	51	60	55.5
Perceived quality as supported by brand equity	64	63	63.5
Mean	**55.4**	**59.8**	**57.6**
Standard Deviation	**8.905**	**11.167**	

In this regard, the research attempted to evaluate the effect of the quality of the solar PV products on the uptake of the solar PV systems. Five variables were used to test the contribution of quality of products on the uptake of the solar PV systems. They included rated performance of the solar PV product, reliability of the solar PV product, aesthetics of the solar PV product, durability of the product as covered by warranty and the Perceived quality as supported by brand equity. The respondents were asked to evaluate the contribution of quality variables to the uptake of solar PV systems. The respondents were given options of rating the variables from 1 to 5, where 1 had the heaviest weight and 5 had the least weight. In the analysis, scale number 1 was rated at 80 %, 2 was rated at 64%, 3 was rated at 48%, 4 was rated at 32% while scale number 5 was rated at 16 %. The scores from each respondent for each variable were added and then averaged to come up with the overall points.

In the findings, perception of quality has been ranked as the highest contributor to the uptake of solar photovoltaic products. This implies that most people would opt to use the solar photovoltaic system products if they perceive them to be of good quality. The least factor among the quality issues is the rated performance of the solar photovoltaic product. In essence, it might mean that the users do not necessarily look at the rated quality of the products and they might be relying on perceptions than the facts. On the other hand, it could mean that the respondents don’t trust that the rated performance is the actual performance of the unit.

The standard deviation of the scores from the contractors was 8.905 while that of the scores from the importers and vendors was 11.167. This implies that the values from both the respondents deviate considerably from the mean. This could mean that there are outliers in the data. From the standard deviation values, it can be postulated that the contractors’ scores are closer to the mean than those of the importers and the vendors. The contractors mostly deal with the installation and maintenance of the solar photovoltaic systems as opposed to importers and vendors who act as middle men between those who manufacture the products and those who use them. The issue of quality could therefore mean different things to the importers. The degree of the difference in meaning of quality has been manifested in the values of the standard deviation. Contractors have a more cohesive concept of quality and uptake of solar photovoltaic products compared to importers.

From the studies, it has been verified that the quality of solar photovoltaic systems is vital to the consumers. It is of essence that the products being supplied to the people meet its utility functions. Nieuwenhout et al (2001), while assessing the solar photovoltaic uptake issues in developing countries, found out that system failure was a contributing factor to the uptake of solar photovoltaic systems. System failure was related to the poor quality product. The products did not meet the stipulated market standards. The authors state that there is need for standardization of the solar products in order to achieve quality and increase the uptake of the systems in developing countries. In Guatemala for instance, customers complained about the low quality products and the lack of technical assistance. Mulugetta et al (2000) report similar findings in Zimbabwe where the poor quality of solar systems was stated to be an impediment of diffusion of the technology. In Kenya, the same reason could affect the uptake of solar photovoltaic systems.

Pearce et al (2012) share the same thoughts as those of Nieuwenhout et al (2001) about solar photovoltaic system quality and their rate of uptake. These thoughts reflect the findings in this study which state that quality of solar photovoltaic system can affect the willingness of the consumers to adopt it. The author states that the benefits of high quality solar photovoltaic systems surpass those of other sources of energy like thermal generators and wind turbines. In this ream therefore, the adoption of solar photovoltaic system is partly based on the quality of the products based in the market. Makrides et al (2010) found out that quality of solar photovoltaic systems affected the uptake of the same even in countries with high solar irradiation.

4.2.3 Government Incentives on solar PV products and uptake of solar PV systems

The researched postulated that the incentives given by the government was an important factor that contributed to the uptake of solar photovoltaic products. Based on five parameters, the subjects were compiled and presented as shown on Table 4.7 below.

Table 4.7: The effects of government incentives on uptake of solar photovoltaic products

Government Incentive Determinants	Percentage Score from Contractors	Percentage Score from Importers and Distributors	Mean Percentage Score
Import tax exemptions	76	65	70.5
Tax holidays for the solar companies	56	73	64.5
Feed in tariffs policy	54	62	58
Net metering policy	59	65	62
Financial assistance	62	45	53.5
Mean	61.4	62	61.7
Standard Deviation	8.7	10.34	6.44

Five variables related to government incentives were tested where the respondents were asked to rank their importance. They were given options of 1 to 5. 1 was the highest while 5 was the lowest in value. In the analysis, scale number 1 was rated at 80 %, 2 was rated 64%, 3 was rated 48%, 4 was rated 32% while scale number 5 was rated at 16 %. The scores from each respondent for each variable were added and then averaged to come up with the overall points.

The results indicate that import tax exemptions have the highest effects on the uptake of solar photovoltaic products in the country. To this end, the exemptions of tax affect the prices of the solar photovoltaic products. The financial assistance variable scored the lowest. Financial assistance advanced by governments towards companies dealing with solar photovoltaic products may not affect the uptake of the same.

The deviation of the scores from contractors is smaller, at 8.7 when compared to the scores from importers and vendors, who have a score of 10.34. These deviations are confounding because the government incentives in Kenya could be affecting the importers and vendors than the contractors. As such, it is expected that the importers and vendors could have a far less uniform opinion about the government incentives as compared to contractors. The duty waiver of import taxes is the most salient incentivization program from the government. This in effect affects the importers and vendors mostly and their opinion would be expected to be more compact, with lesser standard deviation figures.

The findings of this study show that the government is an important stakeholder in the solar photovoltaic system uptake in the country. If the government incentives are scaled up in the whole supply chain of the systems, then the uptake can be improved. Findings by a study conducted by Zahedi (2006) support this argument. In the findings, the author states that countries that improved in their uptake of green energy have done so partly due to the intervention of governments. Governments have intervened using policies such as tax holidays, tax rebates and duty exemptions on the companies dealing with the solar photovoltaic products. In the same breath, the solar photovoltaic system uptake in Kenya has been affected by the government incentives. However, the magnitude of this effect has to be studied closely using inferential research and statistics.

Branker et al's (2011) studies have also contributed to the issue of government incentives by discussing the issue of preferential rates of purchase of solar photovoltaic system electricity from developers. According to these findings, the fit in tariffs for solar electricity have been used by governments as one of the ways of encouraging the uptake of solar photovoltaic systems in their countries. In this regard therefore, it can be largely agreed that the uptake of solar photovoltaic systems depends partly on the incentives offered by the government to the users and the producers of the product.

Solangi et al (2011) reported that governments can improve the uptake of solar photovoltaic systems through incentivizing the stakeholders. One such incentive is the development of research centers for development of the photovoltaic systems. This would help improve the uptake of the systems. Zhang & He (2013) have backed up this argument by citing several examples in China where local authorities have helped improve the solar photovoltaic system uptake using incentives.

4.2.4 Awareness of the solar PV technologies and uptake of solar PV systems

The study sought to find out the effect of the awareness of solar photovoltaic products and the existing regulatory framework on the uptake of solar photovoltaic systems. Five variables were tested and the responses recorded as below Table 4.8.Table 4.8: Awareness of the solar PV technologies

Awareness of the solar PV technologies	Percentage Score from Contractors	Percentage Score from Importers and Distributors	Mean Percentage Score
Cognizance of the PV technologies	54	48	51
Retails distribution points of the Solar PV products	64	65	64.5
Advertisements of the solar PV products	68	47	57.5
Familiarity with ERC regulations	43	68	55.5
Sales force knowledge of the solar PV industry	59	57	58
Mean	57.6	57	57.3
Standard Deviation	9.7	9.6	

The respondents were asked to rank the importance of the variables to the uptake of the solar photovoltaic systems. They were requested to rank the variables using 1 to 5. Number 1 had the highest ranking and number 5 had the lowest ranking. Number 1 was rated at 80 %, 2 was rated at 64%, 3 was rated at 48%, 4 was rated at 32% while scale number 5 was rated at 16 %. The scores from each respondent for each variable were added and then averaged to come up with the overall points.

After the test of this variable, it was found that the availability of the solar photovoltaic system retail outlets played a crucial role in the uptake of solar photovoltaic products. This indicates that the supply chain function of the solar photovoltaic business contributes to the awareness of the public about the product which in turn affects its uptake. Cognizance of the product scored the lowest among the variables that determine the uptake of the solar photovoltaic products. From the results, it can be stated that the knowledge and understanding of the solar photovoltaic system technology does not necessarily affect its uptake.

In this response, it is found that the standard deviation is almost similar, one at 9.7 and the other at 9.6. This implies that the responses deviate from the mean with a similar magnitude. The issue of awareness touches on the marketing function of solar photovoltaic systems. The two strata in this study seem to have similar focus of views about the effect of the awareness on the uptake of solar photovoltaic systems. The level of agreement of scores is almost similar between the contractors and the importer and the vendors of solar photovoltaic systems. This therefore suggests that most players have fair understandings of the effect of system awareness on the uptake of the solar photovoltaic system.

Awareness of the solar photovoltaic systems and their working process can be a contributing factor to their uptake. As shown in Table 4.8, there are different variables of awareness that determine the uptake of the solar photovoltaic systems. The cognizance of the systems is one of the variables. This finding has been supported by Faiers & Neame (2006) who uses the diffusion theory to elaborate on the effect of perception on uptake. It is suggested that performance of the solar photovoltaic products is affected by the perceptions of consumers. Perceptions are in turn affected by the awareness of the customers.

Cotal et al (2000) observed that cost and expenditure perceptions affect the uptake of solar photovoltaic systems in the world. In their study, the authors observed that consumers think of high efficiency solar panels as costly. Such perceptions are said to be false but they nonetheless affect the uptake of the systems. Wamukonya (2007) also found out that perception has largely influenced the reception, level of scrutiny and acceptability of solar home systems projects in Africa. Pinkse & Van Den Buuse's (2012) findings reported that perception does not only affect the laypeople when it comes to adoption of solar photovoltaic systems. The authors found out that oil companies also had perceptions about the cost and performance of the solar photovoltaic systems. Most of the articulated perceptions were said to be unfounded.

4.2.5 Grid access

The researcher hypothesized that the grid access factors could affect the uptake of solar photovoltaic system products. In the study, two factors that were thought to affect the uptake of the products were tested and recorded as shown below on T able 4.9.

Table 4.9: Grid access and uptake of solar PV

Grid access	Percentage Score from Contractors	Percentage Score from Importers and Distributors	Mean Percentage Score
Proximity to National grid	67	56	61.5
Future national grid development plans	45	54	49.5
Mean	56	55	55.5
Standard Deviation	5.7	1.2	

The proximity of areas of the national grid and the future national grid development plans were tested. The respondents were requested to rank these two factors on a scale of 1 to 5 where 1 denoted the highest score and 5 the lowest score. During the analysis, the values were allocated percentage scores with 1 rated 80%, 2 rated at 64%, 3 rated at 48%, 4 rated at 32% while 5 was rated at 16%. The results were analyzed. The contractors opined that the proximity of national grid to the areas had a 67 % effect on the uptake of solar photovoltaic products in the country. The importers and distributors ranked the factor at 56 %. The future national grid development plans was ranked at 45 % by the contractors and 54% by the importers and distributors. The results show that in case there is a national grid line in a given area, then the uptake of solar photovoltaic system could be affected. The lack of the same can also affect the uptake of the solar photovoltaic system technology.

The standard deviations of the scores from contractors and that of the scores from the importers and vendors have differed significantly. Whereas the scores from the importers and the vendors are all close to the mean, with a standard deviation of 1.2, those from the contractors deviate by a magnitude of 5.7. This is as well confounding because grid access mostly affects the contractors as opposed to the importers and the vendors. The contractors should have a more uniform understanding of the effects of grid access on uptake of solar photovoltaic system uptake.

If a grid line is available, then the possibility of the solar photovoltaic system uptake is low. From the study, it is clear that solar photovoltaic systems can only thrive in areas where gird penetration is limited. The same findings have been articulated in Germany where stand-alone solar photovoltaic systems are found to be in high prevalence compared to grid connected systems Bhandari & Stadler, (2009). This implies that most development of such systems only take place in areas with limited grid access.

Del Río & Unruh (2007) shares similar opinion by stating that grid access is one of the issues that lock out development of solar photovoltaic systems in Spain. Areas that are already connected to the national grid find it difficult to come up with solar plants because private development of grids is limited. Similarly, in the Kenyan scenario, as indicated by the results of the study, grid access affects the uptake of the solar photovoltaic systems. Policies should be developed to ensure that areas connected to the national grid have access to the solar photovoltaic systems to augment the existing infrastructure.

Bhandari &Stadler (2011) differ with these assertions and state that access to the grid in Nepal does not necessarily mean that the citizens are getting enough supply of electricity. It does not therefore necessarily mean that grid access should impede the uptake of solar photovoltaic system. Zahedi (2011) is of a similar opinion and he states that areas that are already connected to the grid should be an incentive to the development of grid connected solar power.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This research sought to find out the factors that affect the uptake of solar photovoltaic system in Nairobi. Presented in this chapter is a summary of the research findings, the conclusions and the recommendations for further areas of study. The information in this chapter is presented in three sections.

5.2 Summary of findings

The study tested five variables which were thought to affect the uptake of solar photovoltaic systems in Kenya. The analyzed data shows that these variables affect the uptake of the systems but in varying degrees. Cost was tested as one of the factors that affect the uptake of the solar photovoltaic system. It was ranked with an average score of 58.2 %. The cost of installing the product has a 67 % effect on the uptake of the solar photovoltaic system product. In the study, this was recorded to have the highest effect. The taxes levied on the solar photovoltaic system products had the lowest effect, at 50.5 %. This means that the taxes attracted by the products do not have an effect as significant as that of installation on the uptake of the systems.

The quality of solar photovoltaic system products was also tested to ascertain its effect on the uptake of the system in Kenya. The overall score was 57.6 %. Among the factors that were tested on this variable, the aesthetics of the product was ranked the lowest, at 49.5 %. The highest ranked factor was the reliability of the product. It was ranked at 68 %. The beautiful aspect of the solar products does not have a high effect on the uptake of the solar photovoltaic systems uptake in Nairobi.

The incentives given by the government in the solar photovoltaic system business was considered an important factor in the uptake of the products. Among the five factors tested under the government incentives variable, financial assistance to solar product companies was ranked the lowest. It scored 53.5 %. The import tax exemption was ranked at 70.5 %. This was the highest rated factor among the five tested. The feed in tariff policies, the tax holidays and the net metering policies scored below the tax exemptions' factor.

The awareness of the public about the solar photovoltaic technology can also affect its uptake in the Kenya. Five factors were tested in order to understand the effect of the awareness on the uptake of the system. Averagely, it was found that the public awareness of the solar photovoltaic system had a 57.3 % effect on the uptake of the products in Kenya. The understanding of the science behind the solar photovoltaic system was ranked lowest, at 51 %. The distribution point of the products was ranked as the highest contributing factor to the uptake of solar photovoltaic system products in Nairobi.

The penetration of the national power distribution grid was tested as one of the variables that can affect the uptake of solar photovoltaic products. Two factors were tested under this variable. The proximity of areas near to the national grid was tested and it was found that it had 61.5 % effect on the uptake of the solar photovoltaic systems. The plans to construct grid in other areas was also tested. The data showed that the factor had a 49.5 % effect on the uptake of the solar photovoltaic system products.

5.3 Conclusion

From the results of the study, this research concludes that five variables affect the uptake of solar photovoltaic products in Kenya. Cost, government incentives, the proximity to the grid, the public awareness of the products and the quality all affect the uptake of the solar photovoltaic system in Kenya. These variables however affect the uptake of the systems in different magnitudes. The government incentives have the highest effect on the uptake of the solar photovoltaic products. The proximity of the grid to areas has the least effect, among the tested variables, on the uptake of solar photovoltaic products in Kenya. From the results, it can be concluded that the penetration of the grid is the least among the factors that influence the uptake of solar in Kenya while government incentives have the highest effects of the tested variables on the uptake of the systems.

5.4 Recommendations

This study has helped the researcher understand some of the factors that influence the uptake of solar photovoltaic systems in Kenya. The results are instrumental because they can be the fundamental starting points to any person wishing to understand the factors that influence the uptake of the solar photovoltaic systems in Kenya. However, more work needs to be carried out in order to understand the intricate aspects that influence the uptake of the products. Further studies in the field of solar photovoltaic systems' penetration in Kenya should be considered for further information.

It is important to take measurements of the level of uptake of the systems. Data about the use of the products in Kenya should be collected. This will help researchers come up with inferential analysis about the relationship between the factors that influence the uptake and the uptake itself. This data should be obtained from the government agencies that deal with the taxation regimes, licensing and supervision of solar photovoltaic products. Improved studies should also attempt finding the model that explains the relationship between the uptake of the products and the factors. In such a study, inferential analysis should be used to test the hypothesis about this relationship. This would use a multiple linear regression model. Still, the analysis should have error analysis.

As well, other factors like the nature of buildings in Kenya and the climatic conditions should be analyzed. This stems from the fact that insolation across the country is different. This would in effect affect the uptake of the solar products where areas that receive little insolation may have low uptake of the products. The study should also include collection of views from experts from universities and other research centres.

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APPENDICES

APPENDIX I: LETTER OF INTRODUCTION

27th April, 2015.

Wallace Muchiri Mutwiri
P.O. Box 40889 -00100
Nairobi, Kenya

To: Whom It May Concern

Dear Sir/Madam,

REQUEST FOR DATA COLLECTION

My name is Wallace Muchiri Mutwiri, Reg. No. L50/69483/2013, I am a post-graduate student at the School of Continuing and Distance Education, University of Nairobi. I am conducting a research titled "**DETERMINANTS OF THE UPTAKE OF SOLAR PHOTOVOLTAIC BY ERC LICENCED FIRMS IN KENYA**".

Having been selected for this study, I kindly seek your assistancein filling in the attached questionnaire. The information given will be treated in strict confidence and will be purely used for academic purposes. Do not indicate your names or details on questionnaire.

Your assistance and cooperation will be highly appreciated

Yours sincerely,

……………………………………...

Wallace Muchiri Mutwiri

(Student)L50/69483/2015

APPENDIX II:QUESTIONNAIRE

The purpose of this study is to establish how cost, quality, government incentives, awareness and grid access determine the uptake of solar PV in Kenya.

This questionnaire is a part of Masters of Arts in Project Planning and Management at The University of Nairobi, and is completely anonymous and your answers will be used for academic purposes only and will be treated with strict confidentially. Please indicate the correct option as honestly and as correctly as possible by checking a TICK (√) on one of the options. For the questions that require your opinion, please complete the blanks.

(You are kindly requested to respond to ALL the questions for a valid and reliable research)

PART 1: GENERAL DETAILS

1. Please check/tick category that best describes your company's primary area/sector of business.

Area of Operation	Tick
Solar Products' importers and distributors	
Solar Products Contractor	

2. Designation in the company

Company Head ☐
Sales Manager ☐
Sales Engineer ☐

3. For how many years has your business been in operation?

Less than 1 year ☐

Between 1 and 5 years ☐

More than 5 years ☐

PART 11

The following are the factors that are thought to determine the uptake of solar PV products in Kenya. Kindly give a weight to the factors in terms of the influence by ticking the numbers. Number 1 means the heaviest weight and 5 means the least weight.

1. Cost of solar PV systems and uptake of solar PV

How do the below cost elements determine the uptake of solar PV products in Kenya.	**1**	**2**	**3**	**4**	**5**
The cost of solar PV panels					
The cost of solar PV system accessories					
The installation charges					
Maintenance cost of the solar PV systems					
Taxes levied on the solar PV products					

2. Quality of solar PV products and uptake of Solar PV

Number 1 means the heaviest weight and 5 means the least weight

How do the below quality elements determine the uptake of solar PV products in Kenya	**1**	**2**	**3**	**4**	**5**
Rated performance of the solar PV product					
Reliability of the solar PV product					

Aesthetics of the solar PV product					
Durability of the product as covered by warranty					
Perceived quality as supported by brand equity					

4. **Government Incentives on solar PV products and uptake of solar PV**

   Number 1 means the heaviest weight and 5 means the least weight

How do the below elements of government incentives determine the uptake of solar PV products	**1**	**2**	**3**	**4**	**5**
Import tax exemptions on solar PV products					
Tax holidays for the solar companies					
Feed in tariffs policy					
Net metering policy					
Financial assistance for solar PV companies					

5. **Awareness of the solar PV technologies and uptake of solar PV**

   Number 1 means the heaviest weight and 5 means the least weight

How do the below elements of awareness determine the uptake of solar PV products	**1**	**2**	**3**	**4**	**5**
Cognizance of the PV technologies					
Retails distribution points of the Solar PV products					

Advertisements of the solar PV products					
The number of skilled installers available					
Sales force knowledge of the solar PV industry					

6. Grid access and uptake of solar PV

Number 1 means the heaviest weight and 5 means the least weight

How does the access to the grid determine the uptake of solar PV products	**1**	**2**	**3**	**4**	**5**
Proximity to the national grid					
Future grid development plans					

Thank you for taking time to respond to this questionnaire.

APPENDIX III: MANUFACTURING SHIFT

Below shows the shift with Chinese company dominating the top ten list in 2013.

2006			2013		
Rank	**Company**	**Country**	**Rank**	**Company**	**Country**
1	Sharp	Japan	1	Yingli Green Energy	China
2	Q-Cells	Germany	2	Trina Solar	China
3	Suntech	China	3	Sharp	Japan
4	Motech	Taiwan	4	Canadian Solar	China
5	Solar World	Germany	5	Jinko Solar	China
6	China Sunenergy	China	6	ReneSola	China
7	Kyocera	Japan	7	First Solar	United States
8	Isofoton	Spain	8	Hanwha Solar One	South Korea
9	Schott	Germany	9	Kyocera	Japan
10	Sanyo	Japan	10	JA Solar	China

Source: Dent, C. M. (2014). *Renewable Energy in East Asia: Towards a New Developmentalism*. Routledge.